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TITLE OF THE INVENTION

COMBINED USE OF A GLP-1 AGONIST AND A GASTRIN COMPOUND

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Title: Combined Use of a GLP-1 Agonist and a Gastrin Compound

FIELD OF THE INVENTION

The invention relates generally to compositions, conjugates, and methods comprising a GLP-1 agonist and a gastrin compound, and uses thereof.

5 **BACKGROUND OF THE INVENTION**

Glucagon-like peptide-1 (GLP-1) is a physiological incretin hormone from the lower gastrointestinal tract. GLP-1 has significant physiological activities including stimulation of glucose-dependent insulin secretion, inhibition of glucagon secretion and gastric emptying, inhibition of food intake, enhancement of glucose utilization, 10 preservation of beta cells, inhibition of beta cell apoptosis, and induction of beta cell proliferation. [See Nauck, M.A. Acta Diabetol, 1998, 35:117-129; Holst J.J. Diabetes Metab Res Rev 2002, 18:430-441; Reimer, R.A. et al, Endocrinology 142(10): 4522-4528; Drucker, D.J. , Molecular Endocrinology, 2003, 17(2) 161-171, and <http://www.glucagon.com> for reviews of GLP-1.] The above stated activities of GLP-1 15 make it a highly desirable therapeutic agent for the treatment of many conditions and diseases including diabetes, obesity, gastric ulcers, hypertension, chronic heart failure, fluid retentive states, metabolic syndrome, and related diseases and disorders.

The citation of any reference herein is not an admission that such reference is available as prior art to the instant invention.

20 **SUMMARY OF THE INVENTION**

The combination of a GLP-1 agonist and a gastrin compound provides beneficial effects in the treatment of conditions for which either a GLP-1 agonist or a gastrin compound have been demonstrated to have a therapeutic effect, including but not limited to diabetes, hypertension, chronic heart failure, fluid retentive states, metabolic syndrome 25 and related diseases and disorders, and obesity. Combinations of a GLP-1 agonist and a gastrin compound may be selected to provide unexpectedly additive effects or greater than additive effects i.e. synergistic effects.

A composition, conjugate, or combination therapy comprising a GLP-1 agonist and a gastrin compound employing different mechanisms to achieve maximum therapeutic 30 efficacy, may improve tolerance to the therapy with a reduced risk of side effects that may result from higher doses or longer term monotherapies (i.e. therapies with each compound alone). A composition or combination treatment of the invention will permit the use of

lower doses of each compound with reduced adverse toxic effects of each compound. A suboptimal dosage may provide an increased margin of safety, and may also reduce the cost of a drug necessary to achieve prophylaxis and therapy. In addition, the increased convenience of a single combination dosage unit will result in enhanced compliance.

5 Significantly, a composition, conjugate, or combination treatment of the invention provides sustained beneficial effects following treatment. Prolonged efficacy may be evidenced by increased C-peptide production, increases in pancreatic insulin production, and/or about normal blood glucose levels compared with GLP-1 or gastrin alone.

10 The invention contemplates a composition, preferably a pharmaceutical composition, comprising a GLP-1 agonist and a gastrin compound which provide beneficial effects relative to each compound alone. A pharmaceutical composition may optionally comprise a pharmaceutically acceptable carrier, excipient, or vehicle.

15 In an aspect the invention provides a pharmaceutical composition, comprising a GLP-1 agonist and a gastrin compound that provide beneficial effects, preferably sustained beneficial effects, following treatment. In an embodiment, the sustained beneficial effects are evidenced by one or more of the following: (a) an increase in C-peptide production, (b) an increase in pancreatic insulin production, and/or (c) about normal blood glucose levels compared with GLP-1 or gastrin alone.

20 The invention also provides a pharmaceutical composition in separate containers and intended for simultaneous or sequential administration to provide beneficial effects, preferably sustained beneficial effects, comprising a GLP-1 agonist and a gastrin compound, both optionally together with pharmaceutically acceptable carriers, excipients, or vehicles.

25 The invention also provides a pharmaceutical composition for the treatment of a disease or condition comprising a therapeutically effective amount of a GLP-1 agonist and a gastrin compound in a pharmaceutically acceptable carrier, excipient, or vehicle.

30 In another aspect the invention provides a combination treatment for treating or preventing a condition or disease in a subject comprising administering to the subject a therapeutically effective amount of at least one GLP-1 agonist and a gastrin compound to provide beneficial effects. In an aspect the invention provides a combination treatment which provides sustained beneficial effects following treatment.

The invention provides a conjugate comprising a GLP-1 agonist linked to a gastrin compound to provide beneficial effects, preferably sustained beneficial effects described herein.

5 The invention also provides methods for preparing compositions and conjugates of the invention that result in compositions and conjugates with beneficial effects, preferably sustained beneficial effects.

The invention additionally provides a method of preparing a stable pharmaceutical composition of a GLP-1 agonist adapted to provide beneficial effects, preferably sustained beneficial effects, following treatment, comprising preparing a composition comprising the
10 GLP-1 agonist, a gastrin compound, and a pharmaceutically acceptable carrier, excipient, or vehicle effective to physically stabilize the GLP-1 agonist.

The invention also contemplates the use of a composition or conjugate of the invention or combination treatment of the invention for preventing, and/or ameliorating disease severity, disease symptoms, and/or periodicity of recurrence of a disease or
15 condition described herein. The invention also relates to the prevention and treatment, in a subject, of diseases or conditions using the compositions, combination treatments, and conjugates of the invention.

The invention provides a method of treating a disease or condition comprising administering a GLP-1 agonist and a gastrin compound, a composition or conjugate of the
20 invention with a plurality of cells to a subject in need thereof to thereby produce beneficial effects, preferably sustained beneficial effects. In an embodiment, the compounds/composition/conjugate are administered systemically.

The invention also relates to a method for expanding and differentiating stem cells or progenitor cells into insulin secreting cells comprising contacting the stem cells or
25 progenitor cells with a GLP-1 agonist and a gastrin compound or a composition or conjugate of the invention in sufficient amounts to expand and differentiate stem cells or progenitor cells. The amount of expansion and differentiation may be significantly different compared with that achieved in the absence of the compounds, composition or conjugate. In an embodiment, the stem cells or progenitor cells are contacted with the
30 compounds, composition, or conjugate in culture. In another embodiment, the stem cells or progenitor cells are contacted with the compounds, composition, or conjugate in a subject. The compounds, composition or conjugate may be administered to a subject before,

during, or after implantation of stem cells in the subject to expand and differentiate the stem cells in the subject.

5 The invention also relates to a method for enhancing proliferation of insulin secreting cells in culture comprising contacting the cells with a GLP-1 agonist and a gastrin compound or a composition or conjugate of the invention in sufficient amounts to enhance proliferation of the cells. The amount of proliferation may be significantly different compared with that achieved in the absence of the compounds, composition or conjugate.

10 The invention also relates to a method for sustaining islet cells or precursor cells in culture comprising culturing the cells in the presence of a GLP-1 agonist and a gastrin compound or a composition or conjugate of the invention in an amount sufficient to sustain the cells in culture. The cells may be sustained in culture for a significantly longer period of time compared with cells cultured in the absence of the compounds, composition or conjugate. Culturing cells in the presence of a GLP-1 agonist and a gastrin compound or
15 a composition or conjugate of the invention will be particularly useful in preparing and maintaining cells intended for transplantation.

The invention further relates to a method for treating a subject with a disease or condition described herein comprising contacting *ex vivo* a plurality of cells with a GLP-1 agonist and a gastrin compound, or a composition or conjugate of the invention, optionally
20 culturing the cells, and administering the cells to the subject in need thereof.

The invention still further relates to inducing islet neogenesis in a subject comprising contacting islet precursor cells with a GLP-1 agonist and a gastrin compound, composition, or conjugate of the invention in a sufficient amount to increase proliferation of islet precursor cells in the subject thereby inducing islet neogenesis.

25 The invention provides methods for treating diabetes mellitus in a patient in need thereof by administering a composition comprising a gastrin compound and a GLP-1 agonist in an amount sufficient to effect differentiation of the patient's pancreatic islet precursor cells to mature insulin-secreting cells and/or to stimulate insulin synthesis in existing islet cells. The composition can be administered systemically or expressed *in situ*
30 by host cells containing a nucleic acid construct in an expression vector wherein the nucleic acid construct comprises a coding sequence for a gastrin compound or a coding

sequence for a GLP-1 agonist, together with transcriptional and translational regulatory regions functional in pancreatic islet precursor cells.

Also provided are methods and compositions for treating diabetes in a patient in need thereof by implanting into a diabetic patient pancreatic islet cells that have been
5 exposed in culture to a sufficient amount of a gastrin compound and a GLP-1 agonist to increase the number of pancreatic beta cells in the islets; optionally the population of pancreatic beta cells can be grown in culture for a time sufficient to expand the population of β -cells prior to transplantation.

Since the present invention relates to a method of treatment comprising a
10 combination of active agents which may be administered separately or as conjugates, the invention also provides a kit comprising a GLP-1 agonist and a gastrin compound, a pharmaceutical composition, or conjugate of the invention in kit form.

The invention also contemplates the use of a composition comprising a combination of at least one GLP-1 agonist and at least one gastrin compound for the
15 preparation of a medicament for preventing or treating a condition or disease. In an embodiment, the invention relates to the use of synergistically effective amounts of at least one GLP-1 agonist, and at least one gastrin compound for the preparation of a medicament for preventing or treating a condition or disease. The invention additionally provides uses of a pharmaceutical composition and a conjugate of the invention in the preparation of
20 medicaments for the prevention and/or treatment of diseases and conditions. The medicaments provide beneficial effects, preferably sustained beneficial effects following treatment.

These and other aspects, features, and advantages of the present invention should be apparent to those skilled in the art from the following drawing and detailed description.

25 DESCRIPTION OF THE DRAWINGS

The invention will be better understood with reference to the drawing in which:

Figure 1 is a graph showing the effect of islet neogenesis therapy using a GLP-1 agonist and a gastrin compound (INT-2) on fasting blood glucose in acutely diabetic NOD mice.

30 DEFINITIONS

The recitation of numerical ranges by endpoints herein includes all numbers and fractions subsumed within that range (e.g. 1 to 5 includes 1, 1.5, 2, 2.75, 3, 3.90, 4, and 5).

It is also to be understood that all numbers and fractions thereof are presumed to be modified by the term "about." Further, it is to be understood that "a," "an," and "the" include plural referents unless the content clearly dictates otherwise. Thus, for example, reference to a composition containing "a compound" includes a mixture of two or more
5 compounds.

Selected compounds described herein contain one or more asymmetric centers and may give rise to enantiomers, diastereomers, and other stereoisomeric forms which may be defined in terms of absolute stereochemistry as (R)- or (S)-. Therefore, the invention includes all such possible diastereomers and enantiomers as well as their racemic and
10 optically pure forms. Optically active (R)- and (S)-isomers may be prepared using chiral synthons or chiral reagents, or resolved using conventional techniques. When the compounds described herein contain centers of geometric asymmetry, and unless specified otherwise, it is intended that the compounds include both E and A geometric isomers. All
tautomeric forms are intended to be included within the scope of the invention.

15 The terms "subject", "individual" or "patient" refer to an animal including a warm-blooded animal such as a mammal, which is afflicted with or suspected of having or being pre-disposed to a disease or a condition as described herein. Preferably, the terms refer to a human. The terms also include domestic animals bred for food or as pets, including horses, cows, sheep, poultry, fish, pigs, cats, dogs, and zoo animals. The methods herein
20 for use on subjects/individuals/patients contemplate prophylactic as well as curative use. Typical subjects for treatment include persons susceptible to, suffering from or that have suffered a condition or disease described herein.

The term "pharmaceutically acceptable carrier, excipient, or vehicle" refers to a medium which does not interfere with the effectiveness or activity of an active ingredient
25 and which is not toxic to the hosts to which it is administered.

"Pharmaceutically acceptable salt(s)," includes salts of acidic or basic groups which may be present in the compounds suitable for use in the present invention. Examples of pharmaceutically acceptable salts include sodium, calcium and potassium salts of carboxylic acid groups and hydrochloride salts of amino groups. Other
30 pharmaceutically acceptable salts of amino groups are hydrobromide, sulfate, hydrogen sulfate, phosphate, hydrogen phosphate, dihydrogen phosphate, acetate, succinate, citrate,

tartrate, lactate, mandelate, methanesulfonate (mesylate) and p-toluenesulfonate (tosylate) salts.

The term "about" means plus or minus 0.1 to 50%, 5-50%, or 10-40%, preferably 10-20%, more preferably 10% or 15%, of the number to which reference is being made.

5 The term "preventing or treating" refers to the administration to a subject of biologically active agents either before or after onset of a condition or disease. A treatment may be either performed in an acute or chronic way.

A "beneficial effect" refers to an effect of a combination of a GLP-1 agonist and a gastrin compound, or composition or conjugate thereof, that is greater than the effect of
10 either of the compounds alone. The beneficial effect includes favorable pharmacological and/or therapeutic effects, and improved pharmacokinetic properties and biological activity. A beneficial effect may be an additive effect or synergistic effect. In preferred embodiments of the invention, beneficial effects include but are not limited to the following: reduced or absent islet inflammation, decreased disease progression, increased
15 survival, or cure of a disease or condition. In a particularly preferred embodiment, the beneficial effect is a "sustained beneficial effect" where the beneficial effect is sustained for a prolonged period of time after termination of treatment. In an embodiment, one or more of the aforementioned effects are sustained for a prolonged period of time after termination of treatment. A beneficial effect may be sustained for at least about 2 to 4
20 weeks, 2 to 8 weeks, 2 to 12 weeks, 2 to 24 weeks, 2 weeks to 12 months, and 2 weeks to 18 months following treatment. The period of time a beneficial effect is sustained may correlate with the duration and timing of the treatment. A subject may be treated continuously for about 2 to 8 weeks, 2 to 12 weeks, 2 to 16 weeks, 2 weeks to 6 months, 2 weeks to 12 months, or periodically. A sustained beneficial effect may manifest as one or
25 more of increased C-peptide production, increased pancreatic insulin production, and about normal or low blood glucose levels for a prolonged period following treatment.

The beneficial effect may be a statistically significant effect in terms of statistical analysis of an effect of the two compounds versus the effects of each of the compounds. "Statistically significant" or "significantly different" effects or levels with two compounds
30 compared with each compound alone may represent levels that are higher or lower than a standard. In embodiments of the invention, the difference may be 1.5, 2, 3, 4, 5, or 6 times higher or lower compared with the effect obtained with each compound alone.

An "additive effect" of a GLP-1 agonist and a gastrin compound refers to an effect that is equal to the sum of the effects of the two individual compounds

A "synergistic effect" of a GLP-1 agonist and a gastrin compound refers to an effect that is greater than the additive effect which results from the sum of the effects of
5 the two individual compounds.

A "combination treatment" or "administering in combination" means that the active ingredients are administered concurrently to a patient being treated. When administered in combination each component may be administered at the same time, or sequentially in any order at different points in time. Therefore, each component may be
10 administered separately, but sufficiently close in time to provide the desired effect, in particular a beneficial, additive, or synergistic effect. The first compound may be administered in a regimen which additionally comprises treatment with the second compound.

"Therapeutically effective amount" relates to the amount or dose of active
15 compounds (e.g. GLP-1 agonist and gastrin compound) or compositions or conjugates of the invention that will lead to one or more desired beneficial effects, preferably one or more sustained beneficial effects.

"Suboptimal dose" or suboptimal dosage" refers to a dose or dosage of an active compound which is less than the optimal dose or dosage for that compound when used in
20 monotherapy.

An "analog" refers to a polypeptide wherein one or more amino acid residues of a parent polypeptide have been substituted by another amino acid residue, one or more amino acid residues of a parent polypeptide have been inverted, one or more amino acid residues of the parent polypeptide have been deleted, and/or one or more amino acid
25 residues have been added to the parent peptide. Such an addition may be at either of the N-terminal or C-terminal end or within the parent polypeptide, or a combination thereof.

A "derivative" refers to a polypeptide in which one or more of the amino acid residues of a parent polypeptide have been chemically modified. A chemical modification includes adding chemical moieties, creating new bonds, and removing chemical moieties.
30 A polypeptide may be chemically modified, for example, by alkylation, acylation, glycosylation, pegylation, ester formation, deamidation, or amide formation.

In the present context, "a GLP-1 agonist" is understood to refer to any compound, including peptides and non-peptide compounds, which fully or partially activate the human GLP-1 receptor. In a preferred embodiment, the "GLP-1 agonist" is any peptide or non-peptide small molecule that binds to a GLP-1 receptor, preferably with an affinity constant (KD) or a potency (EC₅₀) of below 1 μ M, for example, below 100 nM as measured by methods known in the art (see e.g. WO 98/08871) and exhibits insulinotropic activity, where insulinotropic activity may be measured *in vivo* or *in vitro* assays known to those of ordinary skill in the art.

A "GLP-1 agonist" includes naturally occurring or synthetic GLP-1 polypeptides, fragments, analogs, derivatives, and pharmaceutically acceptable salts thereof, and active metabolites and prodrugs of GLP-1. U.S. Patent No. 5,118,666 discloses GLP-1 agonists such as GLP-1(7-34) and GLP-1(7-35).

In reference to the nomenclature of analogs and derivatives, for example, Gly⁸-GLP-1(7-37) designates a fragment of GLP-1 derived from GLP-1(7-37) by deleting the amino acid residues at positions 1 to 6, and substituting the amino acid residue in position 8 (Ala) by Gly.

Examples of analogs and derivatives of GLP-1 (including exendin-3 and exendin 4 analogs and derivatives) which can be used according to the present invention include those listed in Table 1 and also in WO 98/08871, WO 99/43705 (Novo Nordisk), WO 99/43706 (Novo Nordisk), WO 99/43707 (Novo Nordisk), WO 99/43708 (Novo Nordisk), WO 99/43341 (Novo Nordisk), PCT/DK99/00081 (Novo Nordisk A/S), PCT/DK99/00082 (Novo Nordisk A/S), PCT/DK99/0085 (Novo Nordisk A/S), WO 98/008871 (Novo Nordisk A/S), WO 87/06941 (The General Hospital Corporation), WO 90/11296 (The General Hospital Corporation), WO 91/11457 (Buckley et al), WO98/43658 (Eli Lilly & Co), EP 0708179-A2 (Eli Lilly & Co), WO 03/035099 (Eli Lilly & Co), WO 01/98331 (Eli Lilly & Co), EP 0699686-A2 (Eli Lilly & Co), US 2003/0224983 (Novo Nordisk A/S), , US 6268343 (Novo Nordisk A/S), US 200302249883-A1 (Novo Nordisk A/S), US 20030119734 A1 (Novo Nordisk A/S), US20040018975A1 (Eli Lilly & Co.), US 20030083259 A1 (Novo Nordisk A/S), US 20010006943-A1 (Novo Nordisk A/S), PCT/CA03/ 33595 (Transition Therapeutics), WO 99/43708, WO 00/66629, WO 01/04146, US Patent Nos. 5,977,071, 5,545,618, 5,705,483, 5,977,071, and 6,133,235;

Adelhorst et al, J.Biol Chem. 1994, 269:6275; and Xiao, Q. et al, 2001, Biochemistry 40:2860-2869, which are incorporated herein by reference.

A "gastrin compound" is understood to refer to any compound, including peptides and non-peptide compounds, which fully or partially associate and/or activate the
5 gastrin/CKK receptor. A gastrin compound may be selected that is a peptide or non-peptide small molecule that has a suitable IC_{50} , for example an IC_{50} of about ~ 0.7 nM at a gastrin/CKK receptor, as measured by methods known in the art (see Singh et al (1995) J. Biol. Chem. 270: 8429-8438, and Kopin et al (1995) J. Biol. Chem. 270: 5019-5023 describing in vitro cell growth assays, and receptor binding assays as described in Singh et
10 al (1995) J. Biol. Chem. 270: 8429-8438, and Kopin et al (1995) J. Biol. Chem. 270: 5019-5023).

A "gastrin compound" includes the various forms of gastrin, such as gastrin 34 (big gastrin), gastrin 17 (little gastrin), and gastrin 8 (mini gastrin), pentagastrin, tetragastrin and fragments, analogs, and derivatives thereof. Examples of gastrin compounds that
15 may be used in the present invention include the compounds disclosed in U.S. Patent No. 6,288,301. In some applications of the invention, a gastrin compound may be selected that is a peptide or non-peptide agonist or partial agonist of the gastrin receptor such as A71378 (Lin et al., Am. J. Physiol. 258 (4 Pt 1): G648, 1990). In some applications of the invention, a gastrin compound may be selected that is a gastrin/CCK receptor ligand
20 including but not limited to cholecystokinin (CCK) such as CCK 58, CCK 33, CCK 22, CCK 12 and CCK 8; and the like.

A gastrin compound also includes active analogs, fragments and other modifications, which for example share amino acid sequence with an endogenous mammalian gastrin, for example, share 60% sequence identity, or 70% identity, or 80%
25 identity. Such compounds also include substances that increase the secretion of endogenous gastrins, cholecystokinins or similarly active peptides from sites of tissue storage. Examples of these are the gastric releasing peptide, omeprazole which inhibits gastric acid secretion, and soya bean trypsin inhibitor which increases CCK stimulation

Sequences for gastrins including big gastrin-34 (Bonato et al , 1986, Life Science
30 39:959) and small gastrin-17 (Bentley et al (1966) Nature 209:583) are shown in SEQ ID NOs. 5-9. Big gastrin-34 is essentially an extension of an amino acid sequence at the N-terminal end of small gastrin-17. Big gastrin is cleaved *in vivo* to release gastrin-17. Glp

at the N-terminal end is pyroglutamate, which is a naturally cyclized form of glutamate. In various embodiments, where cysteine or lysine are added to a terminus of gastrin having a pyroglutamate, the pyroglutamate is replaced with a glutamate, or the pyroglutamate is deleted. Further, each of a gastrin 34 and gastrin-17 can be used having a methionine or a leucine at position 15, as shown in SEQ ID NOs: 5-8 herein.

“Condition(s)” and/or “disease(s)” refer to one or more pathological symptoms or syndromes for which either or both a GLP-1 agonist or a gastrin compound provide a therapeutic effect. The condition or disease may require reduction of blood glucose levels, inhibition of gastric acid secretion, inhibition of apoptosis of β -cells, stimulation of proliferation or differentiation of β -cells, and reduction of body weight. Examples of conditions and diseases include but are not limited to dyslipidemia, hyperglycemia, severe hypoglycemic episodes, stroke, left ventricular hypertrophy, arrhythmia, bacteraemia, septicemia, irritable bowel syndrome, functional dyspepsia, diabetes, catabolic changes after surgery, stress induced hyperglycemia, gastric ulcers, myocardial infarction, impaired glucose tolerance, hypertension, chronic heart failure, fluid retentive states, metabolic syndrome and related diseases and disorders, obesity, diabetic complications as well as symptoms of other diseases in which tissue is damaged due to elevated glucose levels, including Alzheimer’s Disease, Parkinson’s Disease, and other age-related, tissue-degenerative diseases, as well as the arterogenic effects of elevated leptin, for example in patients with impaired glucose tolerance and obese non-diabetic patients.

The term, “diabetes” as used herein means any manifested symptoms of diabetes in any mammal including experimental animal models, and including human forms such as type I and type II diabetes, early stage diabetes, and a pre-diabetic condition characterized by mildly decreased insulin or mildly elevated blood glucose levels. A “pre-diabetic condition” describes a subject demonstrating a symptom in terms of insulin or glucose level, and/or demonstrating a susceptibility to diabetes or a related condition due to family history, genetic predisposition, or obesity in the case of type II diabetes, and includes a subject who has previously had diabetes or a related condition and is subject to risk of recurrence.

“Insulinotropic activity” refers to an ability of a substance to stimulate insulin secretion in response to elevated glucose levels to produce or increase glucose uptake by cells and decreased serum glucose or blood glucose levels. Methods known in the art can

be employed to assay for insulintropic activity. For example, *in vitro* and *in vivo* methods may be used that measures GLP-1 receptor binding activity or gastrin receptor binding activity, receptor activation (see the methods described in EP 619,322 to Gelfand et al and US Patent No. 5,120,712), insulin or C-peptide levels. Compounds, compositions or
5 conjugates described herein have insulintropic activity if islet cells secrete insulin in the presence of the compounds, compositions, or conjugates above background levels or levels in the absence of the compounds, compositions, or conjugates.

"Islet neogenesis" means formation of new beta cells by differentiation, which may or may not have the characteristics of stem cells which have the ability to reproduce in an
10 unlimited manner.

DETAILED DESCRIPTION OF EMBODIMENTS OF THE INVENTION

The invention is related to compositions, conjugates, and methods that utilize a GLP-1 agonist and a gastrin compound to provide beneficial effects.

The compositions, conjugates and methods of the invention provide enhanced
15 beneficial effects, in particular sustained beneficial effects relative to a GLP-1 agonist and/or a gastrin compound alone. In embodiments of the invention, the beneficial effects are additive or synergistic.

In an embodiment, where the disease or condition is diabetes, sustained beneficial effects of a composition, combination treatment, or conjugate of the invention may
20 manifest as one or more of the following:

- An increase in pancreatic insulin levels relative to the levels measured in the absence of the active compounds or for each compound alone after administration to a subject with symptoms of diabetes. Preferably the compounds together induce at least about a 0.05%, 0.1%, 0.5%, 1%, 2%,
25 5%, 10%, 15%, 20%, 30%, 33%, 35%, 40%, 45%, or 50% increase in pancreatic insulin levels in a subject.
- A reduction of an absence of symptoms of islet inflammation after administration to a subject with symptoms of diabetes.
- A decrease in blood glucose levels relative to the levels measured in the
30 absence of the compounds or for each compound alone in subjects with symptoms of diabetes. Preferably, the compounds induce at least about a 2%, 5%, 10%, 15%, 20%, 30%, 40%, 50%, 60%, 70%, 80%, or 90%

decrease in blood glucose levels. Most preferably, the compounds yield blood glucose levels about or close to the levels common in a normal subject.

- 5 • An increase in C-peptide levels relative to the levels measured in the absence of the compounds or for each compound alone in subjects with symptoms of diabetes. Preferably, the compounds together induce at least about a 0.05%, 0.1%, 0.5%, 1%, 2%, 5%, 10%, 15%, 20%, 30%, 33%, 35%, 40%, 45%, or 50% increase in C-peptide levels.
- 10 • Maintenance of blood glucose levels at about normal for a prolonged period of time.
- A reduction, prevention, or slowing of the rate of disease progression in a subject with diabetes.
- A reduction or prevention of the development of severe hyperglycemia and ketoacidosis with symptoms of diabetes.
- 15 • An increase in survival in a subject with symptoms of diabetes.

One or more of these beneficial effects can be demonstrated in a diabetic subject or disease model, for example a non-obese (NOD) mouse with symptoms of diabetes.

20 A gastrin compound is selected for particular embodiments in the present invention and to provide a specific beneficial effect(s) based on characteristics including its insulinotrophic activity, the ability to augment the activity of a GLP-1 agonist (in particular to enhance the insulinotropic effects of a GLP-1 agonist), and/or increase the physical or chemical stability of a GLP-1 agonist. A gastrin compound can also be selected based on its ability to stimulate proliferation/differentiation of beta cells, and its *in vivo* half-life.

25 In an embodiment of the invention, the gastrin compound is gastrin 17 and analogs and derivatives thereof. In a particular embodiment, the gastrin compound is synthetic human gastrin I having 17 amino acid residues with a Leu residue at amino acid position 15.

30 Gastrin compounds may be synthesized by chemical synthesis using techniques well known in the chemistry of proteins such as solid phase synthesis (Merrifield, 1964, J. Am. Chem. Assoc. 85:2149-2154) or synthesis in homogenous solution (Houbenweyl, 1987, Methods of Organic Chemistry, ed. E. Wansch, Vol. 15 I and II, Thieme,

Stuttgart). The synthesis may be performed using manual procedures or by automation. Automated synthesis may be carried out, for example, using an Applied Biosystems 431A peptide synthesizer (Perkin Elmer). Gastrin compounds may also be obtained from commercial sources. For example, synthetic human gastrin 17 with methionine or leucine at position 15 are available from Bachem AG, Bubendorf, (Switzerland), and from Research Plus Inc (New Jersey, USA).

A GLP-1 agonist may be selected for particular applications in the present invention based on one or more of the following characteristics: ability to bind to the GLP-1 receptor, preferably with an affinity constant K_d less than about 1 μ M, more preferably less than about 100nM; ability to initiate a signal transduction pathway resulting in insulinotropic activity; insulinotropic activity; stimulation of beta cell proliferation/differentiation; resistance to DP IV cleavage; and, an *in vivo* half-life of at least about 15 minutes to 24 hours, preferably 2 to 10 hours or 2 to 8 hours in humans using conventional methods (see for example, the method described in US 2003/0144206)

An amino acid portion of a GLP-1 agonist can be prepared by a variety of methods known in the art such as solid-phase synthesis, purification of GLP-1 agonists from natural sources, recombinant technology, or a combination of these methods. See for example, United States Patent Nos. 5,188,666, 5,120,712, 5,523,549, 5,512,549, 5,977,071, 6,191,102, Dugas and Penney 1981, Merrifield, 1962, Stewart and Young 1969, and the references cited herein.

In an embodiment of the invention the GLP-1 agonist is a naturally truncated GIP-1 polypeptide ((GLP-1(7-37) and GLP-1(7-36)amide) [SEQ ID NO. 10 and 2, respectively], or an analog or derivative thereof. The sequences of these naturally occurring truncated GLP-1 agonists are represented in SEQ ID NOs. 1 and 2. In aspects of the invention, a GLP-1 agonist may have the amino acid sequence of SEQ ID NOs. 1 or 2 modified so that amino acid residues at positions 1-20, preferably 1-15, more preferably 1-10, most preferably 1-5 differ from the sequences of SEQ ID NOs. 1 or 2.

In another embodiment of the invention, the GLP-1 agonist is an analog of GLP-1(7-37) or GLP-1(7-36) which has less than 10 amino acid residues that are different from those in GLP-1(7-37) or GLP-1(7-36), less than 5 amino acid residues that are different from those in GLP-1(7-37) or GLP-1(7-36), less than 3 amino acid residues that are

different from those in GLP-1 (7-37) or GLP-1(7-36), preferably only one amino acid residue that is different from sequence of GLP-1(7-37) or GLP-1(7-36).

GLP-1 agonists that may have specific utility in the present invention include polypeptides where one or more amino acids have been added to the N-terminus and/or C-terminus of GLP-1(7-37) or GLP-1(7-36). Preferably, about one to six amino acids may be added to the N-terminus and/or from about one to eight amino acids may be added to the C-terminus. In certain applications GLP-1 agonists are selected that have up to 39 amino acids. Amino acids at positions 1-6 of an extended GLP-1 agonist may be selected so that they are the same or are conservative substitutions of the amino acid at the corresponding positions of the parent GLP-1(7-37) or GLP-1(7-36). Amino acids at positions 38-45 of an extended GLP-1 agonist may be selected so that they are the same or conservative substitutions of the amino acids at the corresponding positions of exendin-3 or exendin-4 (SEQ ID NO. 3 and 4 respectively).

In aspects of the invention a GLP-1 agonist is utilized comprising a position 8 analog wherein the backbone for such analogs or fragments thereof contain an amino acid other than alanine. The amino acid at position 8 may be selected from glycine, valine, leucine, isoleucine, serine, threonine, or methionine

In an embodiment, GLP-1 agonists are selected that have the sequence GLP-1(7-37)OH and GLP-1(7-36) amide, and the corresponding position 8 analogs wherein the backbone for such analogs contains an amino acid other than alanine. The amino acid at position 8 may be selected from glycine, valine, leucine, isoleucine, serine, threonine, or methionine, preferably valine or glycine. The analogs may additionally contain (a) an amino acid at position 22 selected from glutamic acid, lysine, aspartic acid, arginine, and preferably glutamic acid or lysine; (b) an amino acid at position 30 selected from glutamic acid, aspartic acid, serine, or histidine; (c) an amino acid at position 37 selected from lysine, arginine, threonine, glutamic acid, aspartic acid, serine, tryptophan, tyrosine, phenylalanine, or histidine; and/or (d) amino acid at position 27 selected from alanine, lysine, arginine, tryptophan, tyrosine, phenylalanine, or histidine.

A group of GLP-1 analogs and derivatives for use in the present invention comprises the GLP-1 agonists described in U.S. Pat. No. 5,545,618 and US Patent Application Serial No. 20040018975. The analogs include active GLP-1 peptides, 7-34, 7-35, 7-36 and 7-37 having amino acid substitutions as positions 7-10 and/or are truncations

at the C-terminus and/or contain various other amino acid substitutions in the basic peptide. Preferred analogs include those with D-amino acid substitutions in the 7 and 8 positions and/or N-alkylated or N-acylated amino acids in the 7 position since they are particularly resistant to degradation *in vivo*.

5 In another embodiment of the invention at least one amino acid of a GLP-1 agonist has at least one substituent attached directly or indirectly (e.g. via a spacer such as γ -Glu or β -Ala). A substituent is generally selected to make the profile of action of the parent GLP-1 agonist more protracted, make the GLP-1 agonists more metabolically and physically stable, and/or increase solubility of the GLP-1 agonist. An example of a particular
10 substituent is a lipophilic substituent including but not limited to an alkyl group, a group which has an ω -carboxylic acid group, an acyl group of a straight-chain or branched fatty acid or alkane such as tetradecanoyl, hexadecanoyl. Particular compositions, conjugates and treatments of the invention use GLP-1 agonists with lipophilic substituents such as those described in W0 99/43341 (Novo Nordisk) and US 2003/0119734A1 (Novo
15 Nordisk). In a particular embodiment, the GLP-1 agonist is Arg³⁴Lys²⁶(N^ε(γ -Glu(N^α-hexadecanoyl)))-GLP-1(7-37).

In embodiments of the invention, the GLP-1 agonist is selected from the group consisting of: Gly⁸-GLP-1(7-36)-amide, Gly⁸-GLP-1(7-37), Val⁸-GLP-1(7-36)-amide, Val⁸-GLP-1(7-37), Val⁸Asp²²-GLP-1(7-36)-amide, Val⁸Asp²²-GLP-
20 1(7-37), Val⁸Glu²²-GLP-1(7-36)-amide, Val⁸Glu²²-GLP-1(7-37), Val⁸Lys²²-GLP-1(7-36)-amide, Val⁸Lys²²-GLP-1(7-37) -Val⁸Arg²²-GLP-1(7-36)-amide, Val⁸Arg²²-GLP-1(7-37), Val⁸His²²-GLP-1(7-36)-amide, -Val⁸His²²-GLP-1(7-37), Arg²⁶-GLP-1(7-37); Arg³⁴-GLP-1(7-37); Lys³⁶-GLP-1(7-37); Arg^{26,34}Lys³⁶-GLP-1(7-37); Arg^{26,34}-GLP-1(7-37); Arg^{26,34}Lys⁴⁰-GLP-1(7-
25 37); Arg²⁶Lys³⁶-GLP-1(7-37); Arg³⁴Lys³⁶-GLP-1(7-37); Val⁸Arg²²-GLP-1(7-37); Met⁸Arg²²-GLP-1(7-37); Gly⁸His²²-GLP-1(7-37); Val⁸His²²-GLP-1(7-37); Met⁸His²²-GLP-1(7-37); His³⁷-GLP-1(7-37); Gly⁸-GLP-1(7-37); Val⁸-GLP-1(7-37); Met⁸-GLP-1(7-37); Gly⁸Asp²²-GLP-1(7-37); Val⁸Asp²²-GLP-1(7-37); Met⁸Asp²²-GLP-1(7-37); Gly⁸Glu²²-GLP-1(7-37); Val⁸-GLP-1(7-37);
30 Gly⁸Lys²²-GLP-1(7-37); Val⁸Lys²²-GLP-1(7-37); Glu²²Met⁸Glu²²-GLP-1(7-37); Gly⁸Lys²²-GLP-1(7-37); Val⁸Lys²²-GLP-1(7-37); Met⁶Lys²²-GLP-1(7-37); Gly⁸Arg²²-GLP-1(7-37); Val⁸Lys²²His³⁷-GLP-1(7-37); Gly⁸Glu²²His³⁷-

- GLP-1(7-37); Val⁸Glu²²His³⁷-GLP-1(7-37); Met⁸Glu²²His³⁷-GLP-1(7-37); Gly⁸Lys²² His³⁷-GLP-1(7-37); Met⁸Lys²²His³⁷-GLP-1(7-37); Gly⁸Arg²²His³⁷-GLP-1(7-37); Val⁸Arg²²His³⁷-GLP-1(7-37); Met⁸Arg²²His³⁷-GLP-1(7-37); Gly⁸His²²His³⁷-GLP-1(7-37); Val⁸His²²His³⁷-GLP-1(7-37);
- 5 Met⁸His²²His³⁷-GLP-1(7-37); Gly⁸His³⁷-GLP-1(7-37); Val⁸His³⁷-GLP-1(7-37); Met⁸His³⁷-GLP-1(7-37); Gly⁸Asp²²His³⁷-GLP-1(7-37); Val⁸Asp²²His³⁷-GLP-1(7-37); Met⁸Asp²²His³⁷-GLP-1(7-37); Arg²⁶-GLP-1(7-36)-amide; Arg³⁴-GLP-1(7-36)-amide; Lys³⁶-GLP-1(7-36)-amide; Arg^{26,34}Lys³⁶-GLP-1(7-36)-amide; Arg^{26,34}-GLP-1(7-36)-amide;
- 10 Arg^{26,34}Lys⁴⁰-GLP-1(7-36)-amide; Arg²⁶Lys³⁶-GLP-1(7-36)-amide; Arg³⁴Lys³⁶-GLP-1(7-36)-amide; Gly⁸-GLP-1(7-36)-amide; Val⁸-GLP-1(7-36)-amide; Met⁸-GLP-1(7-36)-amide; Gly⁸Asp²²-GLP-1(7-36)-amide; Gly⁸Glu²²His³⁷-GLP-1(7-36)-amide; Val⁸Asp²²-GLP-1(7-36)-amide; Met⁸Asp²²-GLP-1(7-36)-amide; Gly⁸Glu²²-GLP-1(7-36)-amide; Val⁸Glu²²-GLP-1(7-36)-amide; Met⁸Glu²²-GLP-1(7-36)-amide; Gly⁸Lys²²-GLP-1(7-36)-amide; Val⁸Lys²²-GLP-1(7-36)-amide; Met⁸Lys²²-GLP-1(7-36)-amide; Gly⁸His²²His³⁷-GLP-1(7-36)-amide; Gly⁸Arg²²-GLP-1(7-36)-amide; Val⁸Arg²²-GLP-1(7-36)-amide; Met⁸Arg²²His³⁷-GLP-1(7-36)-amide; Gly⁸His²²-GLP-1(7-36)-amide; Val⁸His²²-GLP-1(7-36)-amide;
- 20 Met⁸His²²-GLP-1(7-36)-amide; His³⁷-GLP-1(7-36)-amide; Val⁸Arg²²His³⁷-GLP-1(7-36)-amide; Met⁸Arg²²His³⁷-GLP-1(7-36)-amide; Gly⁸His³⁷-GLP-1(7-36)-amide; Val⁸His³⁷-GLP-1(7-36)-amide; Met⁸His³⁷-GLP-1(7-36)-amide; Gly⁸Asp²²His³⁷-GLP-1(7-36)-amide; Val⁸Asp²²His³⁷-GLP-1(7-36)-amide; Met⁸Asp²²His³⁷-GLP-1(7-36)-amide; Val⁸Glu²²His³⁷-GLP-1(7-36)-amide; Met⁸Glu²²His³⁷-GLP-1(7-36)-amide; Gly⁸Lys²²His³⁷-GLP-1(7-36)-amide; Val⁸Lys²²His³⁷-GLP-1(7-36)-amide; Met⁸Lys²²His³⁷-GLP-1(7-36)-amide; Gly⁸Arg²²His³⁷-GLP-1(7-36)-amide; Val⁸His²²His³⁷-GLP-1(7-36)-amide; Met⁸His²²His³⁷-GLP-1(7-36)-amide; Val⁸-GLP-1(7-37)OH, Gly⁸-GLP-1(7-37)OH, Glu²²-GLP-1(7-37)OH, Asp²²-GLP-1(7-37)OH, Arg²²-GLP-1(7-37)OH, Lys²²-GLP-1(7-37)OH, Cys²²-GLP-1(7-37)OH, Val⁸-Glu²²-GLP-1(7-37)OH, Val⁸-Asp²²-GLP-1(7-37)OH, Val⁸-Arg²²-GLP-1(7-37)OH, Val⁸-Lys²²-GLP-1(7-37)OH, Val⁸-Cys²²-GLP-1(7-37)OH, Gly⁸-Glu²²-GLP-1(7-37)OH, Gly⁸-Asp²²-GLP-1(7-37)OH, Gly⁸-Arg²²-GLP-

1(7-37)OH, Gly⁸-Lys²²-GLP-1(7-37)OH, Gly⁸-Cys²²-GLP-1(7-37)OH, Glu²²-GLP-1(7-36), NH₂, ASP²²-GLP-1(7-36)NH₂, Arg²²-GLP-1(7-36)NH₂, Lys²²-GLP-1(7-36)NH₂, Cys²²-GLP-1(7-36)NH₂, Val⁸-Glu²²-GLP-1(7-36)NH₂, Val⁸-Asp²²-GLP-1(7-36)NH₂, Val⁸-Arg²²-GLP-1(7-36)NH₂, Val⁸-Lys²²-GLP-1(7-36)NH₂, Val⁸-Cys²²-GLP-1(7-36)NH₂,
5 Gly⁸-Glu²²-GLP-1(7-36)NH₂, Gly⁸-Asp²²-GLP-1(7-36)NH₂, Gly⁸-Arg²²-GLP-1(7-36)NH₂, Gly⁸-Lys²²-GLP-1(7-36)NH₂, Gly⁸-Cys²²-GLP-1(7-36)NH₂, Lys²³-GLP-1(7-37)OH, Val⁸-Lys²³-GLP-1(7-37)OH, Gly⁸-Lys²³-GLP-1(7-37)OH, His²⁴-GLP-1(7-37)OH, Val⁸-His²⁴-GLP-1(7-37)OH, Gly⁸-His²⁴-GLP-1(7-37)OH, Lys²⁴-GLP-1(7-37)OH, Val⁸-Lys²⁴-GLP-1(7-37)OH, Gly⁸-Lys²³-GLP-1(7-37)OH, Glu³⁰-GLP-1(7-37)OH, Val⁸-Glu³⁰-GLP-1(7-37)OH, Gly⁸-Glu³⁰-GLP-1(7-37)OH, Asp³⁰-GLP-1(7-37)OH, Val⁸-Asp³⁰-GLP-1(7-37)OH, Gly⁸-Asp³⁰-GLP-1(7-37)OH, Gln³⁰-GLP-1(7-37)OH, Val⁸-Gln³⁰-GLP-1(7-37)OH, Gly⁸-Gln³⁰-GLP-1(7-37)OH, Tyr³⁰-GLP-1(7-37)OH, Val⁸-Tyr³⁰-GLP-1(7-37)OH, Gly⁸-Tyr³⁰-GLP-1(7-37)OH, Ser³⁰-GLP-1(7-37)OH, Val⁸-Ser³⁰-GLP-1(7-37)OH, Gly⁸-Ser³⁰-GLP-1(7-37)OH, His³⁰-GLP-1(7-37)OH, Val⁸-His³⁰-GLP-1(7-37)OH, Gly⁸-His³⁰-GLP-1(7-37)OH, Glu³⁴-GLP-1(7-37)OH, Val⁸-Glu³⁴-GLP-1(7-37)OH, Gly⁸-Glu³⁴-GLP-1(7-37)OH, Ala³⁴-GLP-1(7-37)OH, Val⁸-Ala³⁴-GLP-1(7-37)OH, Gly⁸-Ala³⁴-GLP-1(7-37)OH, Gly³⁴-GLP-1(7-37)OH, Val⁸-Gly³⁴-GLP-1(7-37)OH, Gly⁸-Gly³⁴-GLP-1(7-37)OH, Ala³⁵-GLP-1(7-37)OH, Val⁸-Ala³⁵-GLP-1(7-37)OH, Gly⁸-Ala³⁵-GLP-1(7-37)OH, Lys³⁵-GLP-1(7-37)OH, Val⁸-Lys³⁵-GLP-1(7-37)OH, Gly⁸-Lys³⁵-GLP-1(7-37)OH, His³⁵-GLP-1(7-37)OH, Val⁸-His³⁵-GLP-1(7-37)OH, Gly⁸-His³⁵-GLP-1(7-37)OH, Pro³⁵-GLP-1(7-37)OH, Val⁸-Pro³⁵-GLP-1(7-37)OH, Gly⁸-Pro³⁵-GLP-1(7-37)OH, Glu³⁵-GLP-1(7-37)OH, Val⁸-Glu³⁵-GLP-1(7-37)OH, Gly⁸-Glu³⁵-GLP-1(7-37)OH, Val⁸-Ala²⁷-GLP-1(7-37)OH, Val⁸-His³⁷-GLP-1(7-37)OH, Val⁸-Glu²²-Lys²³-GLP-1(7-37)OH, Val⁸-Glu²²-Glu²³-GLP-1(7-37)OH, Val⁸-Glu²²-Ala²⁷-GLP-1(7-37)OH, Val⁸-Gly³⁴-Lys³⁵-GLP-1(7-37)OH, Val⁸-His³⁷-GLP-1(7-37)OH, and Gly⁸-His³⁷-GLP-1(7-37)OH, and derivatives thereof and derivatives thereof.

In a particular embodiment the GLP-1 agonists are Val⁸-GLP-1(7-37)OH, Gly⁸-GLP-1(7-37)OH, Glu²²-GLP-1(7-37)OH, Lys²²-GLP-1(7-37)OH, Val⁸-Glu²²-GLP-1(7-37)OH, Val⁸-Lys²²-GLP-1(7-37)OH, Gly⁸-Glu²²-GLP-1(7-37)OH, Gly⁸-Lys²²-GLP-1(7-37)OH, Glu²²-GLP-1(7-36)NH₂, Lys²²-GLP-1(7-36)NH₂, Val⁸-Glu²²-GLP-1(7-36)NH₂, Val⁸-Lys²²-GLP-1(7-36)NH₂, Gly⁸-Glu²²-GLP-1(7-36)NH₂, Gly⁸-Lys²²-GLP-1(7-36)NH₂,
30 Val⁸-Lys²²-GLP-1(7-36)NH₂, Gly⁸-Glu²²-GLP-1(7-36)NH₂, Gly⁸-Lys²²-GLP-1(7-36)NH₂,

Val⁸-His³⁷-GLP-1(7-37)OH, Gly⁸-His³⁷-GLP-1(7-37)OH, Arg³⁴-GLP-1(7-36)NH₂, and Arg³⁴-GLP-1(7-37)OH.

In another particular embodiment, the GLP-1 agonist is selected from the group consisting of Gly⁸-GLP-1(7-37), Val⁸GLP-1(7-37), Val⁸Asp²²GLP-1(7-37),
5 Val⁸Glu²²GLP-1(7-37), Val⁸Lys²²GLP-1(7-37), and Val⁸His²² GLP-1(7-37), and analogs and derivatives thereof.

In a further particular embodiment, the GLP-1 agonist is selected from the group consisting of Gly⁸-GLP-1(7-36) amide, Val⁸GLP-1(7-36) amide, Val⁸Asp²²GLP-1(7-36) amide, Val⁸Glu²²GLP-1(7-36) amide, Val⁸Lys²²GLP-1(7-36) amide, and Val⁸His²² GLP-
10 1(7-36) amide, and analogs and derivatives thereof.

Pharmaceutical compositions of the invention can be selected that have statistically significant sustained beneficial effects, preferably sustained beneficial effects, compared with a GLP-1 agonist or a gastrin compound alone.

In an embodiment, a pharmaceutical composition with statistically significant
15 beneficial effects, preferably sustained beneficial effects, is provided comprising a GLP-1 agonist selected from the group consisting of Gly⁸-GLP-1(7-37), Val⁸GLP-1(7-37), Val⁸Asp²²GLP-1(7-37), Val⁸Glu²²GLP-1(7-37), Val⁸Lys²²GLP-1(7-37), Val⁸His²² GLP-1(7-37), Arg³⁴Lys²⁶(N^ε(γ-Glu(N^α-hexadecanoyl))) -GLP-1(7-37), Gly⁸-GLP-1(7-36) amide, Val⁸GLP-1(7-36) amide, Val⁸Asp²²GLP-1(7-36) amide, Val⁸Glu²²GLP-1(7-36) amide, Val⁸Lys²²GLP-1(7-36) amide, and Val⁸His²² GLP-1(7-36) amide, and a gastrin
20 compound is selected from the group consisting of gastrin 17 and analogs and derivatives thereof, preferably synthetic human gastrin I having 17 amino acid residues with a Leu residue at amino acid position 15.

In an embodiment, a pharmaceutical composition with statistically significant
25 beneficial effects is provided comprising GLP-1(7-36) and gastrin-17(leu).

In an embodiment, the invention comprises pharmaceutically acceptable salts of a GLP-1 agonist and/or pharmaceutically acceptable salts of a gastrin compound.

In another embodiment, a pharmaceutical composition is provided which has been adapted for administration to a subject to provide sustained beneficial effects to treat a
30 condition or disease, preferably diabetes. In a preferred embodiment, it is in a form such that administration to a subject results in blood glucose levels that are about normal that persist in the subject for a prolonged period of time after cessation of treatment.

In an embodiment, a composition or conjugate comprising a GLP-1 agonist and a gastrin compound have greater sustained insulintropic activity following treatment compared with the activity of a GLP-1 agonist or gastrin compound alone or greater than GLP-1(7-37)OH.

5 This invention provides a conjugate comprising a GLP-1 agonist linked to a gastrin compound wherein the linkage is for example via amino or carboxyl group. The invention also relates to isolated covalent conjugates of the invention, and compositions comprising covalent conjugates of the invention.

10 A GLP-1 agonist may be conjugated to a species via an ester bond between a OH and a COOH of a gastrin compound.

Conjugates of a GLP-1 agonist and a gastrin compound may be conjugated or linked with an intermediate spacer or linker. A suitable spacer or linker may be a mono- or disaccharide, an amino acid, a sulfate, a succinate, an acetate, or an oligomeric polymeric spacer or linker comprising one or more of such moieties.

15 The invention also provides methods of preparing the above covalent conjugates that result in conjugates with improved pharmacokinetic properties, biological activity, and beneficial effects. The methods comprise incubating the GLP-1 agonist with the gastrin compound under conditions that allow formation of a covalent linkage between the two compounds.

20 The invention therefore contemplates a process for preparing a covalent conjugate comprising a GLP-1 agonist covalently bonded or linked to a gastrin compound, the process comprising: incubating the GLP-1 agonist with a gastrin compound under conditions and at a pH and for a time sufficient for formation of a covalent bond or linkage between the GLP-1 agonist and gastrin compound; and isolating the covalent conjugate.

25 The above process for preparing a conjugate comprising a GLP-1 agonist and a gastrin compound provides a conjugate with a substantial amount of a GLP-1 agonist covalently linked to the GLP-1 agonist.

30 N-terminal or C-terminal fusion proteins or chimeric proteins, comprising a GLP-1 agonist conjugated with a gastrin compound, optionally with a spacer or linker, may also be prepared by fusing, through recombinant techniques, the N-terminal or C-terminal sequence of a GLP-1 agonist and the sequence of a gastrin compound.

The invention also provides a conjugate prepared by a process described herein.

The invention also related to pharmaceutical formulations comprising conjugates of the invention and a pharmaceutically acceptable carrier, excipient, or vehicle.

The invention further relates to a pharmaceutical formulation of substantially pure covalent conjugates comprising a GLP-1 agonist covalently linked to a gastrin compound
5 which provides beneficial effects preferably sustained beneficial effects compared to the GLP-1 agonist alone.

In an embodiment, a pharmaceutical formulation is provided consisting essentially of covalent conjugates comprising a GLP-1 agonist covalently linked without an intermediate spacer or linker to a gastrin compound.

10 According to another aspect of the invention, a kit is provided. The kit is a package which houses a container which contains a covalent conjugate of the invention and also houses instructions for administering the covalent conjugate to a subject.

In another aspect the invention provides a combination treatment for treating or preventing a condition or disease in a subject comprising administering to the subject a
15 therapeutically effective amount of at least one GLP-1 agonist and at least one gastrin compound to produce beneficial effects, preferably sustained beneficial effects.

The invention also relates to a method of treatment comprising administering a therapeutically effective amount of at least one GLP-1 agonist in combination with the administration of at least one gastrin compound which upon administration to a subject
20 with symptoms of diabetes produces beneficial effects, preferably sustained beneficial effects, manifested as reduced blood glucose levels and/or increased pancreatic insulin.

In an aspect of the invention therapeutically effective amounts of a GLP-1 agonist and a gastrin compound are combined prior to administration to a subject. In an embodiment, therapeutically effective amounts of a GLP-1 agonist and a gastrin
25 compound are mixed at a physiologically acceptable pH.

The invention also contemplates the use of a composition or conjugate of the invention or combination treatment of the invention for preventing, and/or ameliorating disease severity, disease symptoms, and/or periodicity of recurrence of a disease or condition described herein. The invention also relates to the prevention and treatment, in
30 mammals, of conditions or diseases using the compositions, combination treatments, and conjugates of the invention.

In an embodiment, the invention provides a method for stimulating beta cell proliferation in a subject comprising administering a therapeutically effective amount of a composition or conjugate of the invention, or administering in combination a GLP-1 agonist and a gastrin compound.

- 5 In another embodiment, the invention provides a method for increasing the number and/or size of beta cells in a subject comprising administering a therapeutically effective amount of a composition or conjugate of the invention or administering in combination a GLP-1 agonist and a gastrin compound.

- 10 In a further embodiment, the invention provides a method for preventing or treating Type I or Type II diabetes comprising administering a therapeutically effective amount of a composition or conjugate of the invention, or administering in combination a GLP-1 agonist and a gastrin compound.

- 15 In a still further embodiment, the invention provides a method for ameliorating progression of disease or obtaining a less severe stage of disease in a person suffering from Type II diabetes comprising administering a therapeutically effective amount of a composition or conjugate of the invention, or administering in combination a GLP-1 agonist and a gastrin compound.

- 20 The invention relates to a method of delaying the progression of impaired glucose tolerance or non-insulin requiring Type II diabetes to insulin requiring Type II diabetes comprising administering a therapeutically effective amount of a composition or conjugate of the invention, or administering in combination a GLP-1 agonist and a gastrin compound.

- 25 The invention also relates to a method of increasing the insulin synthesis capability of a subject comprising administering a therapeutically effective amount of a composition or conjugate of the invention, or administering in combination a GLP-1 agonist and a gastrin compound.

- 30 The invention provides methods for treating cells, preferably cells in culture using a GLP-1 agonist and gastrin compound of the invention, or compositions, or conjugates of the invention. The invention also provides cell based treatment methods using a GLP-1 agonist and gastrin compound of the invention, or compositions, or conjugates of the invention. See PCT/CA03/33595 for a description of general culture and cell based treatment methods.

In an aspect, the invention provides a method of treating a disease or condition comprising administering a GLP-1 agonist and a gastrin compound, a composition or conjugate of the invention with a plurality of cells to a subject in need thereof to thereby produce a beneficial effect, preferably a sustained beneficial effect.

5 A method for treating a subject with a disease or condition described herein comprising contacting *ex vivo* a plurality of cells with a GLP-1 agonist and a gastrin compound, or a composition or conjugate of the invention of the invention, optionally culturing the cells, and administering the cells to the subject in need thereof.

10 In embodiments of the aforementioned cell based therapeutic methods the cells are pancreatic ductal cells and the amount of compounds/composition/conjugate used in the method is generally effective to increase the amount of insulin secreting cells in the subject. The cells may be autologous (i.e. from the same subject), or may be from another individual of the same species, or from a different species.

15 The methods of the invention may further comprise measuring one or more of the following markers: blood glucose, serum glucose, blood glycosylated haemoglobin, pancreatic beta cell mass, serum insulin, pancreatic insulin levels, morphometrically determined beta cell mass, amount of insulin secreting cells, and glucose responsiveness of insulin secreting cells.

20 The invention also relates to inducing islet neogenesis in a subject comprising contacting islet precursor cells with a GLP-1 agonist and a gastrin compound, composition, or conjugate of the invention in a sufficient amount to increase proliferation of islet precursor cells in the subject thereby inducing islet neogenesis.

25 The invention also relates to a method for expanding and differentiating stem cells into insulin secreting cells comprising contacting the stem cells with an effective amount of a GLP-1 agonist and a gastrin compound or a composition or conjugate of the invention. The compounds, composition or conjugates may be administered to a subject before, during, or after stem cells are implanted in the subject. The stem cells may be obtained from pancreatic islets, umbilical cords, embryos, or stem cell lines. The method may additionally comprise administering an immunosuppressive agent.

30 The invention contemplates a method of expanding a functional beta cell mass of pancreatic islet transplants in a diabetic patient, the method comprising administering to

the patient a therapeutically effective amount of a GLP-1 agonist and a gastrin compound, or a composition or conjugate of the invention.

The invention also contemplates a method for treating diabetes in a subject comprising transplanting a pancreatic islet preparation into the subject and administering a
5 therapeutically effective amount of a GLP-1 agonist and a gastrin compound, or a composition or conjugate of the invention.

Since the present invention relates to a method of treatment comprising a combination of active agents which may be administered separately or as conjugates, the invention also provides a kit comprising a GLP-1 agonist and a gastrin compound, a
10 pharmaceutical composition or conjugate in kit form. The invention also provides a pharmaceutical kit comprising one bottle with a GLP-1 agonist and another bottle with a gastrin bottle in one box.

The invention also contemplates the use of a composition comprising a combination of at least one GLP-1 agonist and at least one gastrin compound for the
15 preparation of a medicament providing beneficial effects, preferably sustained beneficial effects in treating a condition or disease.

In an embodiment, the invention relates to the use of a therapeutically effective amount of at least one GLP-1 agonist, and at least one gastrin compound for preparation of a medicament for providing beneficial effects, preferably sustained beneficial effects, in
20 treating a condition or disease.

In an embodiment the invention provides the use of a GLP-1 agonist and a gastrin compound for the preparation of a medicament for increase (preferably sustained increase) of the number and/or size of beta cells in a subject after treatment.

In another embodiment the invention provides the use of GLP-1 agonist and a
25 gastrin compound for the preparation of a medicament for stimulation (preferably sustained stimulation) of beta cell proliferation after treatment.

In a still further embodiment the invention provides the use of GLP-1 and Gastrin for the preparation of a medicament for treatment of Type I or Type II diabetes.

The invention additionally provides uses of a pharmaceutical composition and a
30 conjugate of the invention in the preparation of medicaments for beneficial effects, preferably sustained beneficial effects, in the treatment of diseases and conditions.

Therapeutic efficacy and toxicity may be determined by standard pharmaceutical procedures in cell cultures or with experimental animals such as by calculating a statistical parameter such as the ED_{50} (the dose that is therapeutically effective in 50% of the population) or LD_{50} (the dose lethal to 50% of the population) statistics. The therapeutic
5 index is the dose ratio of therapeutic to toxic effects and it can be expressed as the ED_{50}/LD_{50} ratio. Pharmaceutical compositions which exhibit large therapeutic indices are preferred.

The compositions of the present invention can be administered by any means that produce contact of the active agent(s) with the agent's sites of action in the body of a
10 subject or patient. The active ingredients can be administered simultaneously or sequentially and in any order at different points in time, to provide the desired beneficial effects. The compounds, conjugates and compositions can be formulated for sustained release, for delivery locally or systemically. It lies within the capability of a skilled physician or veterinarian to select a form and route of administration that optimizes the
15 effects of the compositions, conjugates, and treatments of the present invention.

The compositions may be administered in oral dosage forms such as tablets, capsules (each of which includes sustained release or timed release formulations), pills, powders, granules, elixirs, tinctures, suspensions, syrups, and emulsions. They may also be administered in intravenous (bolus or infusion), intraperitoneal, subcutaneous, or
20 intramuscular forms, all utilizing dosage forms well known to those of ordinary skill in the pharmaceutical arts. The compositions of the invention may be administered by intranasal route via topical use of suitable intranasal vehicles, or via a transdermal route, for example using conventional transdermal skin patches. A dosage protocol for administration using a transdermal delivery system may be continuous rather than intermittent throughout the
25 dosage regimen.

A preferred route of administration is parenteral administration, more preferably peripheral parenteral administration. Parenteral administration is generally understood to refer to the injection of a dosage form into the body by a sterile syringe or some other mechanical device such as an infusion pump. For the purpose of the present invention
30 parenteral routes include intravenous, intramuscular, subcutaneous, and intraperitoneal routes of administration. For parenteral administration, the compounds or conjugates described herein may be combined with distilled water at an appropriate pH.

The present invention includes combination treatments providing additive or synergistic activity, delivering an additive or synergistically effective amount, or an amount to provide a therapeutically effective amount of a GLP-1 agonist and a gastrin compound, or a conjugate or composition of the invention. Therefore, pharmaceutical
5 compositions suitable for use in the present invention include compositions wherein the active ingredients are contained in a synergistically effective amount or a therapeutically effective amount.

The dosage regimen of the invention will vary depending upon known factors such as the pharmacodynamic characteristics of the agents and their mode and route of
10 administration; the species, age, sex, health, medical condition, and weight of the patient, the nature and extent of the symptoms, the kind of concurrent treatment, the frequency of treatment, the route of administration, the renal and hepatic function of the patient, and the desired effect. The effective amount of a drug required to prevent, counter, or arrest progression of a condition can be readily determined by an ordinarily skilled physician or
15 veterinarian.

A composition or treatment of the invention may comprise a unit dosage of at least one GLP-1 agonist and a unit dosage of at least one gastrin compound. A "unit dosage" refers to a unitary i.e. a single dose which is capable of being administered to a patient, and which may be readily handled and packed, remaining as a physically and chemically
20 stable unit dose comprising either the active agents as such or a mixture with one or more solid or liquid pharmaceutical excipients, carriers, or vehicles.

In an aspect, a pharmaceutical composition is provided comprising a therapeutically effective suboptimal dosage of a GLP-1 agonist and a gastrin compound that are more effective at decreasing or reducing glucose levels for a sustained period
25 following treatment compared with a dosage of either a gastrin compound or GLP-1 agonist alone.

In another aspect, an improved pharmaceutical composition is provided comprising therapeutically effective suboptimal amounts of a GLP-1 agonist and a gastrin compound in a form for chronic or acute therapy of a disease or condition, in particular diabetes.

30 In an embodiment, the composition comprises a GLP-1 agonist and a gastrin compound in doses that are equal to or at least 1.1, 1.5, 2, 3, 4, 5, 6, 7, 8, 9, or 10 fold

lower than the doses of each compound required to provide beneficial effects, preferably sustained beneficial effects, to treat a disease or condition.

In an aspect the invention provides a pharmaceutical composition comprising between 0.5 to 6000, 100-1500, 100-6000, 1000-6000, 2000-6000, and 3000-6000
5 micrograms GLP-1 agonist per single unit and 0.5 to 6000, 100-3000, 100-6000, 1000-6000, 2000-6000, and 3000-6000 micrograms gastrin compound per single unit.

In another aspect the invention provides a pharmaceutical composition comprising between 0.1 to 20, 0.1 to 30, 0.1 to 40, 0.1 to 50, and 0.1 to 60 micrograms/kg/day GLP-1 and 0.1 to 20, 0.1 to 30, 0.1 to 40, 0.1 to 50, and 0.1 to 60 micrograms/kg/day gastrin
10 compound.

A composition or formulation of the invention may administered to a subject continuously for 2 weeks to 12 months, 2 weeks to 6 months, 2-16 weeks, 2 weeks to 12 weeks, and/or 2-8 weeks, or periodically.

In an embodiment, the ratio of GLP-1 agonist to gastrin compound in a
15 composition of the invention is selected to augment the activity of the GLP-1 agonist and/or gastrin compound and to provide beneficial effects, preferably sustained beneficial effects.

A GLP-1 agonist and a gastrin compound may be in a ratio selected to augment the activity of one or both compounds to produce beneficial effects, preferably an additive or
20 synergistic effect, or beneficial effects, preferably sustained beneficial effects. In particular embodiments, the ratio of a GLP-1 agonist to a gastrin compound may be from 1:1 to 1:110, 1:1 to 1:100, 1:1 to 1:75, 1:1 to 1:50, 1:1 to 1:25, 1:1 to 1:10, 1:1 to 1:5, and 1:1. In other particular embodiments, the ratio of a gastrin compound to a GLP-1 agonist may be from 1:1 to 1:110, 1:1 to 1:100, 1:1 to 1:75, 1:1 to 1:50, 1:1 to 1:25, 1:1 to 1:10, and 1:1 to
25 1:5.

In an embodiment, a GLP-1 agonist may be used in combination with a gastrin compound at therapeutically effective weight ratios of between about 1:1 to 1:150, preferably 1:1 to 1:50. In another embodiment, a gastrin compound may be used in combination with a GLP-1 agonist at therapeutically effective weight ratios of between
30 about 1:1 to 1:150, preferably 1:1 to 1:50.

The compositions of the present invention or fractions thereof typically comprise suitable pharmaceutical diluents, excipients, vehicles, or carriers selected based on the

intended form of administration, and consistent with conventional pharmaceutical practices. The carriers, vehicles etc. may be adapted to provide an additive, synergistically effective or therapeutically effective amount of the active compounds.

Suitable pharmaceutical diluents, excipients, vehicles, and carriers are described in the standard text, Remington's Pharmaceutical Sciences, Mack Publishing Company. By way of example for oral administration in the form of a capsule or tablet, the active components can be combined with an oral, non-toxic pharmaceutically acceptable inert carrier such as lactose, starch, sucrose, methyl cellulose, magnesium stearate, glucose, calcium sulfate, dicalcium phosphate, mannitol, sorbitol, and the like. For oral administration in a liquid form, the drug components may be combined with any oral, non-toxic, pharmaceutically acceptable inert carrier such as ethanol, glycerol, water, and the like. Suitable binders (e.g. gelatin, starch, corn sweeteners, natural sugars including glucose; natural and synthetic gums, and waxes), lubricants (e.g. sodium oleate, sodium stearate, magnesium stearate, sodium benzoate, sodium acetate, and sodium chloride), disintegrating agents (e.g. starch, methyl cellulose, agar, bentonite, and xanthan gum), flavoring agents, and coloring agents may also be combined in the compositions or components thereof.

In an aspect of the invention a pharmaceutical composition has a pH from about 7 to 10.

Formulations for parenteral administration of a composition of the invention may include aqueous solutions, syrups, aqueous or oil suspensions and emulsions with edible oil such as cottonseed oil, coconut oil or peanut oil. Dispersing or suspending agents that can be used for aqueous suspensions include synthetic or natural gums, such as tragacanth, alginate, acacia, dextran, sodium carboxymethylcellulose, gelatin, methylcellulose, and polyvinylpyrrolidone.

Compositions for parenteral administration may include sterile aqueous or non-aqueous solvents, such as water, isotonic saline, isotonic glucose solution, buffer solution, or other solvents conveniently used for parenteral administration of therapeutically active agents. A composition intended for parenteral administration may also include conventional additives such as stabilizers, buffers, or preservatives, e.g. antioxidants such as methylhydroxybenzoate or similar additives.

In an embodiment, a solid form pharmaceutical composition is provided (e.g. tablets, capsules, powdered, or pulverized form) comprising a crystalline or amorphous GLP-1 agonist and a crystalline or amorphous gastrin compound.

5 In another embodiment, the invention relates to a liquid drug formulation comprising pharmaceutically acceptable salts of a GLP-1 agonist and a gastrin compound, and to lyophilized drug formulations that can be reconstituted to provide suspensions that are stable and suitable for parenteral administration.

In a particular embodiment, the invention relates to an aqueous composition comprising pharmaceutically acceptable salts of a GLP-1 agonist and a gastrin compound,
10 and a solvent system which effects solubilization. The invention also provides a drug comprising an aqueous formulation of pharmaceutically acceptable salts of a GLP-1 agonist and a gastrin compound with at least one solubilizer.

A composition of the invention may be sterilized by, for example, filtration through a bacteria retaining filter, addition of sterilizing agents to the composition,
15 irradiation of the composition, or heating the composition. Alternatively, the compounds, conjugates, and compositions of the present invention may be provided as sterile solid preparations e.g. lyophilized powder, which are readily dissolved in sterile solvent immediately prior to use.

In addition to the formulations described herein, the compositions can also be
20 formulated as a depot preparation. Such long acting formulations may be administered by implantation (for example, subcutaneously or intramuscularly) or by intramuscular injection. Thus, for example, the fractions may be formulated with suitable polymeric or hydrophobic materials (for example, as an emulsion in an acceptable oil), or ion exchange resins, or as sparingly soluble derivatives, for example, as a sparingly soluble salt.

25 The compositions of the invention and components thereof may comprise soluble polymers as targetable drug carriers.

After pharmaceutical compositions have been prepared, they can be placed in an appropriate container and labelled for treatment of an indicated condition. For administration of a composition of the invention, such labelling would include amount,
30 frequency, and method of administration.

The present invention also includes methods of using the compositions of the invention in combination with one or more additional therapeutic agents including without

limitation immunosuppressive agents, antiobesity agents, antidiabetic agents, appetite regulating drugs, antihypertensive agents, agents for the treatment and/or prevention of complications resulting from or associated with a condition or disease, in particular diabetes and obesity, anti-nausea, anti-headache medications, and general medications that
5 treat or prevent side effects

The invention will be described in greater detail by way of specific examples. The following examples are offered for illustrative purposes, and are not intended to limit the invention in any manner. Those of skill in the art will readily recognize a variety of noncritical parameters which can be changed or modified to yield essentially the same
10 results.

Example 1

Effects of Gastrin in Combination with GLP-1 (Bachem, GLP-1(7-36) Amide, Human) in Acutely-Diabetic NOD Mice

This example shows methods and compositions for reversing diabetes in diabetic NOD
15 mice by stimulating β -cell neogenesis *in vivo* following systemic treatment with GLP-1 and Gastrin. Female NOD mice ages 12-16 weeks were treated for 18 days only with vehicle (PBS), GLP-1 (300 ug/kg/day), or GLP-1 (300 ug/kg/day) + Gastrin (3 ug/kg/day), by injection intraperitoneally twice daily within 2 days after diabetes onset. Onset of diabetes was determined by fasting blood glucose (FBG) levels (9-15 mM
20 compared with normal FBG <6.0 mM). The mice were monitored daily for urine glucose and weekly for FBG levels.

At the start of the treatments, fasting blood glucose levels ranged between 11-14 mM. After 18 days of treatments, FBG was 24 ± 1 mM in vehicle-treated mice, 13 ± 2 mM in mice treated with GLP-1 alone, and 6 ± 1 mM in mice treated with the combination of
25 GLP-1 and Gastrin (mean \pm SE, n=4 mice in treated groups; n=6 mice in the control group).

After 18 days of treatment therapy was stopped and FBG was monitored weekly for additional six weeks. One week following the completion of treatment, the FBG levels returned to normal in mice injected with the combination therapy, and they remained at
30 such levels throughout the end of the study at six weeks post treatment. Comparatively, the untreated group of animals had to be sacrificed due to the severity of the disease after five weeks. Mice treated with GLP-1 alone showed transient improvement in FBG levels up to

2 weeks after the treatment was stopped, after which the fasting blood glucose levels progressively increased and were similar to the levels observed in non-treated vehicle group by the end of the study.

The results of the study are illustrated in Figure 1.

5 These results show that a short course of a combined GLP-1 and gastrin treatment to diabetic NOD mice normalized hyperglycemia to effectively treat the diabetes, and it had a prolonged effect on fasting blood glucose levels indicating a stimulation of beta cell neogenesis and insulin production.

10 The present invention is not to be limited in scope by the specific embodiments described herein, since such embodiments are intended as but single illustrations of one aspect of the invention and any functionally equivalent embodiments are within the scope of this invention. Indeed, various modifications of the invention in addition to those shown and described herein will become apparent to those skilled in the art from the foregoing
15 description and accompanying drawings. Such modifications are intended to fall within the scope of the appended claims.

20 All publications, patents and patent applications referred to herein are incorporated by reference in their entirety to the same extent as if each individual publication, patent or patent application was specifically and individually indicated to be incorporated by reference in its entirety. The citation of any reference herein is not an admission that such reference is available as prior art to the instant invention.

It must be noted that as used herein and in the appended claims, the singular forms "a", "an", and "the" include plural reference unless the context clearly dictates otherwise.

Table 1

GLP-1 agonist	Source
DAC:GLP-1	Conjuchem
Long-lasting synthetic glucagons-like peptide	Conjuchem
Long-lasting insulinotropic peptides	Conjuchem
AC2592	Amylin Pharmaceuticals/ Restoragen
AC2993 – Exenatide	Amylin Pharmaceuticals
Exendin-4	Eli Lilly, Alkermes, Amylin
NN2211 - GLP-1 (Liraglutide)	Novo Nordisk
ThGLP-1	Theratechnologies
ZP10	Zealand Pharma/ Aventis
Albumin:GLP-1 fusion peptide	Human Genome Sciences
BIM 51077	Roche/Ipsen
N-terminally truncated GLP-1 derivatives & analogs (lipophilic substituent attached)	Novo Nordisk PCT/DK99/00081
Derivatives of GLP-1 analogs with a lipophilic substituent	Novo Nordisk PCT/DK99/00082 US 6,458,924
N-terminally modified GLP-1 derivatives & analogs with lipophilic substituent attached and protracted profile of action (N-terminal end has a substituent comprising an optionally substituted 5- or 6-membered ring system)	Novo Nordisk PCT/DK99/00085
Derivatives of GLP-1 analogs with a lipophilic substituent (protracted profile of action)	Novo Nordisk WO 98/08871
GLP-1 fragment as insulinotropic hormone	The General Hospital Corporation WO 87/06941
GLP-1 derivatives with insulinotropic activity	The General Hospital Corporation WO 90/11296
GLP-1 analogs exhibiting enhanced stability or an enhanced capacity to stimulate insulin production	Buckley et al. WO 91/11457

GLP-1 analogs and derivatives (stimulate the secretion or biosynthesis of insulin in poorly functioning beta cells)	Eli Lilly & Co. EP 0708179-A2
N-terminal truncated GLP-1 and analogs (promote glucose uptake by cells but do not stimulate insulin expression or secretion)	Eli Lilly & Co. EP 0699686 -A2
GLP-1 analogs or derivatives for increasing the number and/or the size of beta cells and for stimulating beta cell proliferation	Novo Nordisk US 2003/0224983
GLP-1 derivatives with a lipophilic substituent and protracted profile of action	Novo Nordisk US 6268343
Pharmaceutical formulations of GLP-1 agonists	Novo Nordisk US 20030119734 A1
GLP-1 amide, fragment, analogue or derivative	Novo Nordisk US 20030083259 A1
GLP-1 compositions having protracted action	Novo Nordisk US 20010006943 A1
GLP-1 & gastrin	Transition Therapeutics PCT/CA03/
Gastrin formulations	Transition Therapeutics PCT/CA03/
Derivatives of GLP-1 analogs with a lipophilic substituent (protracted profile of action)	Novo Nordisk WO 99/43706
GLP-1 and exendin derivatives with just one lipophilic substituent attached to the C-terminal amino acid residue	Novo Nordisk WO 99/43708
Modified exendins and agonists linked to one or more polyethylene glycol polymers	Amylin Pharmaceuticals WO 00/66629
Ecarin, a procoagulant protein from Echis carinatus venom	Cohesion Technologies WO 01/04146
Modified Fragments of GLP-1, exendin 3 and exendin 4	Conjuchem, Inc. US 6,514,500
GLP-1 analogs	Novo Nordisk A/S US 6,451,974
GLP-1 analogs, derivatives and active peptides	Eli Lilly and Company 6,191,102

GLP-1 Fragments	The General Hospital Corporation 6,162,907
GLP-1 molecules associated with a divalent metal cation	Eli Lilly and Company 6,133,235 5,977,071
Buccal delivery systems with GLP-1	Theratech, Inc. 5,863,555
GLP-1 Analogs	Eli Lilly and Company 5,981,488
GLP-1 mimics	Bristol-Myers Squibb Company WO 03/033671
Long lasting GLP-1	Conjuchem, Inc. US 6,593,295 US 6,514,500 US 6,329,336
Precursor GLP-1	Genzyme Corporation WO 03/014318
GLP-1 complexes	Eli Lilly and Company 6,358,924
Modified peptides	Theratechnologies Inc. WO 02/10195
GLP-1 and related molecules	Zealand Pharma A/S WO 2004/005342

WHAT IS CLAIMED IS:

- 5 1. A pharmaceutical composition comprising a GLP-1 agonist and a
 gastrin compound that provides beneficial effects relative to each
 compound alone, and optionally a pharmaceutically acceptable carrier,
 excipient, or vehicle.
2. A pharmaceutical composition as claimed in claim 1 that provides
 sustained beneficial effects.
- 10 3. A pharmaceutical composition as claimed in claim 2 in a form that
 provides normal blood glucose levels in a subject that persist for a
 prolonged period of time after administration.
4. A pharmaceutical composition as claimed in any preceding claim
 comprising therapeutically effective amounts of a GLP-1 agonist and a
15 gastrin compound in a form for chronic or acute therapy of a subject in
 need thereof.
5. A pharmaceutical composition as claimed in claim 4 wherein the
 therapeutically effective amounts are suboptimal relative to the amount
 of each compound administered alone for treatment of diabetes.
- 20 6. A pharmaceutical composition as claimed in any preceding claim
 wherein the ratio of GLP-1 agonist to gastrin compound is selected to
 augment the activity of the GLP-1 agonist or gastrin compound.
7. A pharmaceutical composition as claimed in claim 5 wherein the ratio
 of a GLP-1 agonist to a gastrin compound is from about 1:1 to 1:110,
25 1:1 to 1:100, 1:1 to 1:75, 1:1 to 1:50, 1:1 to 1:25, 1:1 to 1:10, 1:1 to 1:5,
 and 1:1.
8. A pharmaceutical composition as claimed in claim 6 wherein the ratio
 of a gastrin compound to a GLP-1 agonist is from about 1:1 to 1:110,
 1:1 to 1:100, 1:1 to 1:75, 1:1 to 1:50, 1:1 to 1:25, 1:1 to 1:10, and 1:1 to
30 1:5.
9. A pharmaceutical composition as claimed in any preceding claim
 wherein the GLP-1 agonist is used in combination with the gastrin

compound at therapeutically effective weight ratios of between about 1:1.5 to 1:150, preferably 1:2 to 1:50.

- 5
10. A pharmaceutical composition as claimed in any preceding claim wherein the GLP-1 agonist and the gastrin compound are present in doses that are at least about 1.1 to 1.4, 1.5, 2, 3, 4, 5, 6, 7, 8, 9, or 10 fold lower than the doses of each compound alone required to treat a disease or condition.
- 10
11. A pharmaceutical composition as claimed in claim 1 comprising an additive amount or synergistically effective amount of the GLP-1 agonist and the gastrin compound in a pharmaceutically acceptable excipient, carrier, or vehicle.
- 15
12. A pharmaceutical composition as claimed in claim 1 comprising between 0.1 to 20, 0.1 to 30; 0.1 to 40, 0.1 to 50, and 0.1 to 60 micrograms/kg/day GLP-1 agonist and 0.1 to 20, 0.1 to 30, 0.1 to 40, 0.1 to 50, and 0.1 to 60 micrograms/kg/day gastrin compound.
- 20
13. A pharmaceutical composition as claimed in claim 2 wherein the beneficial effects are one or more of the following: reduced or absent islet inflammation, decreased disease progression, increased survival, or decreased symptoms of a disease or condition.
- 25
12. A pharmaceutical composition as claimed in any preceding claim wherein the beneficial effects are sustained beneficial effects that persist for a prolonged period of time after termination of treatment.
- 30
13. A pharmaceutical composition as claimed in claim 13 wherein the beneficial effects are sustained for at least about 2 to 4 weeks, 2 to 8 weeks, 2 to 12 weeks, 2 to 24 weeks, 2 weeks to 12 months, and 2 weeks to 18 months following treatment.
14. A pharmaceutical composition as claimed in claim 13 wherein the sustained beneficial effects may manifest as increased C-peptide production, increased pancreatic insulin production, and about normal or low blood glucose levels for a prolonged period following treatment.
15. A pharmaceutical composition as claimed in any preceding claim wherein the sustained beneficial effects are statistically significant in

terms of statistical analysis of an effect of a GLP-1 agonist and a gastrin compound compared with the effects of each of the compounds.

- 5 17. A pharmaceutical composition as claimed in any preceding claim wherein the beneficial effect is at least about a 0.05%, 0.1%, 0.5%, 1%, 2%, 5%, 10%, 15%, 20%, 30%, 33%, 35%, 40%, 45%, or 50% increase in pancreatic insulin levels.
- 10 18. A pharmaceutical composition as claimed in any preceding claim wherein the beneficial effect is at least about a 2%, 5%, 10%, 15%, 20%, 30%, 40%, 50%, 60%, 70%, 80%, or 90% decrease in blood glucose levels.
- 15 19. A pharmaceutical composition as claimed in any preceding claim wherein the beneficial effect is a decrease in blood glucose levels for a period of at least about about 2 to 4 weeks, 2 to 8 weeks, 2 to 12 weeks, 2 to 24 weeks, 2 weeks to 12 months, and 2 weeks to 18 months following treatment.
- 20 20. A pharmaceutical composition as claimed in any preceding claim wherein the GLP-1 agonist is a GLP-1(1-37), GLP-1(7-36) amide, fragments, analogs, and derivatives thereof, and active metabolites and prodrugs of GLP-1.
- 25 21. A pharmaceutical composition as claimed in any preceding claim wherein the GLP-1 agonist comprises a parent polypeptide of the formula GLP-1(7-R) wherein R is 36, 37, 38, 39, 40, 41, 42, 43, 44, and 45, and wherein optionally up to 5, 10, or 15 amino acid residues are replaced with any α -amino acid residue.
- 30 22. A pharmaceutical composition as claimed in any preceding claim wherein the GLP-1 agonist is an analog or derivative of GLP-1 listed in Table 1.
23. A pharmaceutical composition as claimed in any preceding claim wherein the GLP-1 agonist is GLP-1(7-37) and GLP-1(7-36) amide, and the corresponding Thr⁸, Met⁸, Gly⁸, and Val⁸ analogs thereof .
24. A method for treating or preventing a condition or disease in a subject comprising administering to the subject a therapeutically effective

amount of at least one GLP-1 agonist and a gastrin compound to produce a sustained beneficial effect.

- 5 25. A method of treatment comprising administering to a subject a therapeutically effective amount of at least one GLP-1 agonist in combination with administration of at least one gastrin compound which upon administration to a subject with symptoms of diabetes provides sustained beneficial effects.
- 10 26. A method as claimed in claim 25 wherein administration with of at least one GLP-1 agonist in combination with administration of at least one gastrin compound provides sustained beneficial effects of at least one symptom of diabetes.
- 15 27. A method as claimed in claim 25 wherein therapeutically effective amounts of the GLP-1 agonist and the gastrin compound are combined prior to administration to the subject.
- 20 28. A method as claimed in claim 25 wherein therapeutically effective amounts of the GLP-1 agonist and the gastrin compound are administered to the subject sequentially.
- 25 29. A method as claimed in any preceding claim wherein therapeutically effective amounts of a GLP-1 agonist and a gastrin compound are administered at a physiologically acceptable pH.
- 30 30. A conjugate comprising a GLP-1 agonist linked to a gastrin compound to provide beneficial effects, in particular sustained beneficial effects.
31. A method of preparing a stable pharmaceutical composition of a GLP-1 agonist comprising mixing a GLP-1 agonist, a gastrin compound, and a pharmaceutically acceptable carrier, excipient, or vehicle effective to physically stabilize the GLP-1 agonist and adapted to provide beneficial effects preferably sustained beneficial effects.
32. A method of treating a condition or disease comprising administering a therapeutically effective amount of a GLP-1 agonist and a gastrin compound, or a composition or conjugate of any preceding claim to a subject in need thereof to thereby produce beneficial effects, preferably sustained beneficial effects.

- 5 33. A method of treating a condition or disease comprising administering a GLP-1 agonist and a gastrin compound, or a composition or conjugate of any preceding claim with a plurality of cells to a subject in need thereof to thereby produce beneficial effects, preferably sustained beneficial effects.
- 10 34. A method for treating a subject with a condition or disease comprising contacting *ex vivo* a plurality of cells with a GLP-1 agonist and a gastrin compound, or a composition or conjugate of any preceding claim, optionally culturing the cells, and administering the cells to the subject in need thereof.
- 15 35. A method of any preceding claim wherein the condition or disease is dyslipidemia, hyperglycemia, severe hypoglycemic episodes, stroke, left ventricular hypertrophy, arrhythmia, bacteraemia, septicaemia, irritable bowel syndrome, functional dyspepsia, diabetes, catabolic changes after surgery, stress induced hyperglycemia, gastric ulcers, myocardial infarction, impaired glucose tolerance, hypertension, Alzheimer's disease and other central and peripheral neurodegenerative conditions chronic heart failure, fluid retentive states, metabolic syndrome and related diseases, and disorders and obesity.
- 20 36. A method for inducing islet neogenesis in a subject comprising contacting islet precursor cells with a GLP-1 agonist and a gastrin compound, or a composition, or conjugate of any preceding claim in a sufficient amount to increase proliferation of islet precursor cells in the subject thereby inducing islet neogenesis.
- 25 37. A method for expanding and differentiating stem cells into insulin secreting cells comprising contacting the stem cells with an effective amount of a GLP-1 agonist and a gastrin compound or a composition or conjugate of any preceding claim.
- 30 38. Use of a composition comprising a combination of at least one GLP-1 agonist and at least one gastrin compound for the preparation of a medicament for the treatment of a condition or disease.

39. A use of claim 38 wherein the condition or disease is dyslipidemia, hyperglycemia, severe hypoglycemic episodes, stroke, left ventricular hypertrophy, arrhythmia, bacteraemia, septicaemia, irritable bowel syndrome, functional dyspepsia, diabetes, catabolic changes after surgery, stress induced hyperglycemia, gastric ulcers, myocardial infarction, impaired glucose tolerance, hypertension, Alzheimer's disease and other central and peripheral neurodegenerative conditions chronic heart failure, fluid retentive states, metabolic syndrome and related diseases, and disorders and obesity.

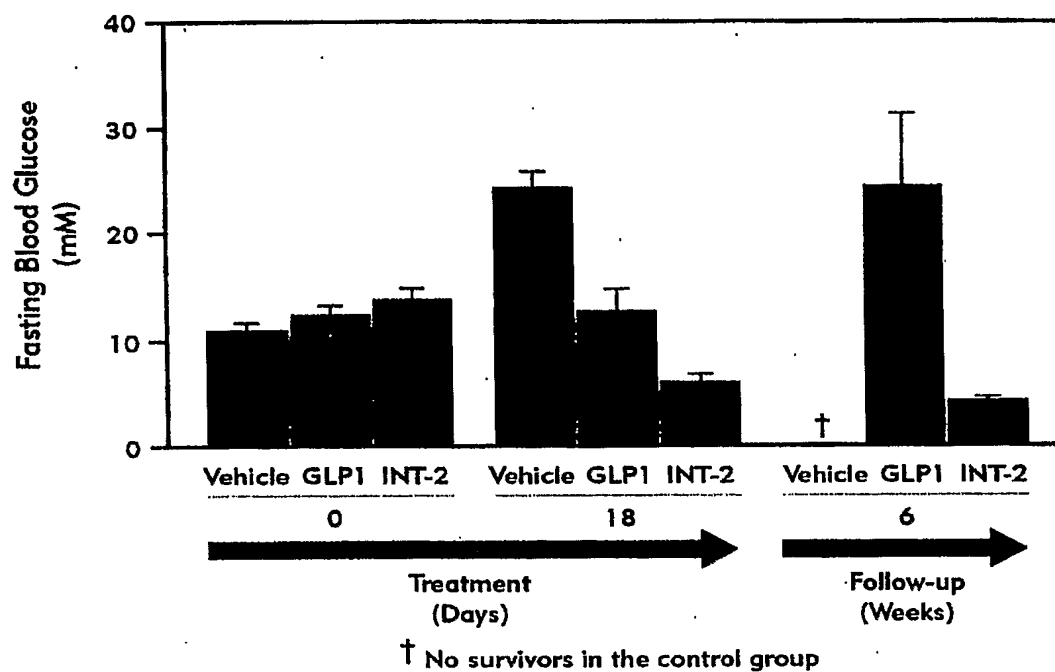
40. A kit form of a composition or conjugate as claimed in any preceding claim.

ABSTRACT OF THE DISCLOSURE

The invention relates generally to compositions and methods comprising a GLP-1 agonist and a gastrin compound, and uses thereof.

5

Figure 1



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Sequence Listing

SEQ ID NO. 1

- 5 GLP-1 (1-37):
His-Asp-Glu-Phe-Glu-Arg-His-Ala-Glu-Gly-Thr-Phe-Thr-Ser-Asp-Val-Ser-Ser-Tyr-Leu-
Glu-Gly-Gln-Ala-Ala-Lys-Glu-Phe-Ile-Ala-Trp-Leu-Val-Lys-Gly-Arg-Gly

SEQ ID NO. 2

- 10 GLP-1 (7-36):
His-Ala-Glu-Gly-Thr-Phe-Thr-Ser-Asp-Val-Ser-Ser-Tyr-Leu-Glu-Gly-Gln-Ala-Ala-Lys-
Glu-Phe-Ile-Ala-Trp-Leu-Val-Lys-Gly-Arg

15 SEQ ID NO. 3

Exendin-3 (*Heloderma horridum horridum*) Genbank Accession No. P20394

1 hsdgtftsdI skqmeeeavr lfiewlknngg pssgappps

20

SEQ ID NO. 4

Exendin-4 (*Heloderma suspectum*) Genbank Accession No. HWGH4G

- 25 1 hgegtftsdI skqmeeeavr lfiewlknngg pssgappps

SEQ ID NO. 5

- 30 N-terminal Glp-Leu-Gly-Pro-Gln-Gly-Pro-Pro-His-Leu-Val-Ala-Asp-Pro-Ser-Lys-Lys-
Gln-Gly-Pro-Trp-Leu-Glu-Glu-Glu-Glu-Glu-Ala-Tyr-Gly-Trp-Met-Asp-Phe

SEQ ID NO. 6

- 35 N-terminal Glp-Leu-Gly-Pro-Gln-Gly-Pro-Pro-His-Leu-Val-Ala-Asp-Pro-Ser-Lys-Lys-
Gln-Gly-Pro-Trp-Leu-Glu-Glu-Glu-Glu-Glu-Ala-Tyr-Gly-Trp-Leu-Asp-Phe

SEQ ID NO. 7

- 40 N-terminal Glp-Gly-Pro-Trp-Leu-Glu-Glu-Glu-Glu-Glu-Ala-Tyr-Gly-Trp-Met-Asp-Phe .
SEQ ID NO. 8

SEQ ID NO. 8

N-terminal Glp-Gly-Pro-Trp-Leu-Glu-Glu-Glu-Glu-Glu-Ala-Tyr-Gly-Trp-Leu-Asp-Phe

45 SEQ ID NO. 9

mqrIcIvIvli falalaafse aswkprsqqp dapIgtganr dlelpwleqq gpashhrrql

gpqgpphlva dpskkqgpwl eeeeeaygwm dfgrsaede n

SEQ ID NO. 10

5 GLP-1 (7-37):

His-Ala-Glu-Gly-Thr-Phe-Thr-Ser-Asp-Val-Ser-Ser-Tyr-Leu-Gly-Gln-Ala-Ala-Lys-
Glu-Phe-Ile-Ala-Trp-Leu-Val-Lys-Gly-Arg-Gly

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